(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 867 412 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
30.09.1998 Bulletin 1998/40

(51) Int Cl.6: C03B 37/029

(21) Application number: 98400666.8

(22) Date of filing: 23.03.1998

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 27.03.1997 US 41728 P

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(54) Thermal insulation of a furnace for drawing optical fibres

(57) The present invention provides an improvement to the thermal insulation of a fiber optic draw furnace having a heating element (22) arranged inside a furnace shell (20) for drawing an optical fiber (F) from a preform (P). The fiber optic draw furnace (10) has one or more pieces of fiber draw furnace insulation (14, 16, 18) to separate the heating element (22) from the furnace shell (20) for reducing the thermal transfer therebetween. At least one of the pieces of fiber draw furnace insulation (14, 16, 18) is made from rigidified high purity graphite felt that provides highly efficient thermal insulation between the heating element (22) and the outer furnace shell (20). The rigidified high purity graphite felt insulation (14, 16, 18) includes either a bottom insulation ring (14), a cylindrical insulation insert (16) or a cylindrical insulation canister (18).

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Description

BACKGROUND OF THE INVENTION

1. Field Of Invention

The present invention relates to a fiber optic draw furnace for making optical fiber; and more particularly to insulators for separating a heating element from an outer furnace shell in graphite resistance and inductance furnaces.

2. Discussion of Related Art

Known graphite resistance fiber optic draw furnaces typically have a standard graphite felt insulation insert that may be nonhomogeneous (density variation). The standard graphite felt insulation is very "dirty" (loose graphite particles and graphite fibers). The standard graphite felt is also very susceptible to moisture and oxygen absorption.

SUMMARY OF THE INVENTION

The present invention provides an improvement to a fiber optic draw furnace having a heating element arranged inside a furnace shell for drawing an optical fiber from a preform. The fiber optic draw furnace has one or more fiber draw furnace insulation to separate the heating element from the furnace shell for reducing the thermal transfer therebetween. At least one of the fiber draw furnace insulation means is made from rigidified high purity graphite felt that provides highly efficient thermal insulation between the heating element and the outer furnace shell. The rigidified high purity graphite felt insulation may include either a bottom insulation ring, a cylindrical insulation insert or a cylindrical insulation canister.

Some advantages of the rigidified high purity graphite felt insulation include the fact that it has less density variation than standard (i.e. non-rigidified) felt, and therefore, has superior temperature uniformity; does not generate loose graphite particles or graphite fiber; and are resistant to moisture and oxygen absorption.

BRIEF DESCRIPTION OF THE DRAWING

The invention, both as to its organization and manner of operation, may be further understood by reference to a drawing (not drawn to scale) which includes Figures 1-4, taken in conjunction with the following description.

Figure 1 is a schematic diagram of a fiber optic draw furnace, which is the subject matter of the present invention.

Figure 2, including Figures 2(a), 2(b) and 2(c), is an illustration of a bottom insulation ring of the fiber optic draw furnace shown in Figure 1.

Figure 3, including Figures 3(a), 3(b) and 3(c), is an illustration of a insulation canister of the fiber optic draw furnace shown in Figure 1.

Figure 4, including Figures 4(a), 4(b), 4(c), is 4(d) are an illustration of an insulation insert shown of the fiber optic draw furnace shown in Figure 1.

BEST MODE OF THE INVENTION

Fiber Optic Draw Furnace 10

Figure 1 shows part of a graphite resistance fiber draw furnace generally indicated as 10 for drawing an optical fiber (F) from a preform (P). The graphite resistance fiber draw furnace 10 includes a graphite liner 12, a bottom insulation ring 14, a cylindrical insulation insert 16, a cylindrical insulation canister 18, a furnace shell 20, a heating element 22, a bottom graphite insulation plate 24, an inner graphite cylinder 26, a power head 28, a top plate assembly 30 and a bottom plate assembly 32.

High Density Extruded Graphite Liner 12

In Figure 1, the high density extruded graphite liner 12 has a cylindrical shape, and the heating element 22 is cylindrical and arranged around the high density extruded graphite liner 12. The graphite liner 12 is a high density extruded graphite liner that is impregnated with vitreous carbon completely through its entire graphite liner matrix. The high density extruded graphite liner 12 provides an improved barrier between the graphite heating element 22 and the fiber optic preform (P) that is comparable to an isomolded graphite liner but much more economical in cost.

High Density Extruded Graphite Heating Element 22

In Figure 1, the heating element 22 is a high density extruded graphite heating element that is impregnated with vitreous carbon completely through its entire graphite heating element matrix, making the graphite furnace 10 effectively a high temperature thermal energy source. The impregnation of a lower grade graphite (low density extruded) with vitreous (glassy) carbon produces a heating element that is comparable in performance and benefits to expensive high density isomolded graphite heating elements with several additional benefits, as discussed above.

Rigidified High Purity

Graphite Felt Insulation 14, 16, 18

In Figure 1, the insulation 14, 16, 18 are made from rigidified high purity graphite felt that provides highly efficient thermal insulation between the graphite heating element 22 and the outer furnace shell 20. Rigidified

high purity graphite felt is known in the art, and consists of a homogeneous mixture of graphite fibers and a graphite-based resin that is solidified. The insulation 14, 16, 18 is shown in greater detail in Figures 2-4, including the bottom insulation ring 14 in Figure 2, the insulation canister 18 in Figure 3 and the insulation insert 16 in Figure 4, and discussed in greater detail below.

The bottom insulation ring 14 in Figure 2 is shown in Figures 2(a), (b), (c) and has a top surface with a thin layer of reflective graphite resin generally indicated as 14a, a ring opening 14b for fitting around the graphite liner 12, and a bottom surface (not shown). The function of the bottom insulation ring 14 is to insulate thermally the bottom of the furnace shell 20 from the high temperature heating element 22. The bottom insulation ring 14 is manufactured by machining the rigidified high purity graphite felt into its final dimensions. The machined material may be then coated on all surfaces with a thin layer of reflective graphite resin generally indicated as 14a that provides enhanced thermal insulating properties, which results in improved efficiency and increased life of the graphite heating element 22. In addition, the coating 14a provides a clean surface free of graphite particles and graphite fibers which is essential for the manufacturing of high strength optical fiber. The coating 14a also adds mechanical strength.

The insulation canister 18 and the insulation insert 16 are respectively shown in Figures 3-4. The function of the insulation insert 16 and the insulation canister 18 is to thermally insulate the side of the furnace shell 20 from the heating element 22. The insulation insert 16 (Figure 4) fits into the inner diameter of the insulation canister 18 (Figure 3). All surfaces are coated with either a reflective graphite resin or a thin layer of reflective graphite foil laminated onto the surface of the rigid insulation material. The reflective graphite resin or the thin layer of reflective graphite foil are generally indicated as 16a, 18a. Similar to the bottom insulation ring 14, the insulation insert 16 and the insulation canister 18 are manufactured by machining the rigidified high purity graphite felt into its final dimensions. The graphite foil and/or reflective coating 16a, 18a on all of their respective surfaces results in improved thermal efficiency of the furnace and increased life of the heating element 22. In addition, the graphite foil and/or reflective coating 16a, 18a provides a clean surface free of graphite particles and graphite fibers which is essential for the manufacturing of high strength optical fiber. The graphite foil and/or reflective coating 16a, 18a also adds mechanical strength.

Other advantages of the insulation ring 14, the graphite felt insulation insert 16 and the insulation canister 18 are that they have less density variation than standard felt, and therefore, have superior temperature uniformity; do not generate loose graphite particles or graphite fibers; and are resistant to moisture and oxygen absorption.

The Two-Piece, TiC Coated, Barrier Plate 24, 26

In Figure 1, the fiber optic draw furnace 10 has a new two-piece barrier including 24, 26 that consists of the bottom graphite insulation plate 24 and the inner graphite cylinder 26. The two-piece barrier 24, 26 is arranged between the heating element 22 and the insulation pieces 14, 16, 18. The inner graphite cylinder 26 is coated on the inner diameter with titanium carbide (TiC).

The TiC coated two-piece barrier 24, 26 may have other applications in glass drawing, and manufacturing processes or industries utilizing graphite resistance furnace technologies.

The graphite resistance fiber optic draw furnace known in the prior art typically has a heating element, furnace insulation and a graphite barrier between the heating element and the furnace insulation for protecting the furnace insulation. The prior art graphite barrier produces graphite particulate that degrades the optical fiber produced therein, has a short heating element life, reduces the life of the furnace insulation, and degrades overall furnace efficiency. In contrast, the new and improved two-piece barrier plate 24, 26 having a TiC coating results in a cleaner furnace environment, which is important for manufacturing high strength optical fiber, longer heating element life, longer life of the furnace insulation, and improved furnace efficiency.

Optimal Liner/Preform Gap Range of 3.5 to 7.5 Millimeters

In Figure 1, the graphite resistance fiber optic draw furnace 10 has an air gap G in a range of 3.5 to 7.5 millimeters (spacing) between an outer surface of the preform (P) and the inside surface of the graphite liner 12 that is maintained to minimize graphite particulate contamination of the preform and fiber during the fiber optic drawing process. The same gap G is also important for minimizing the formation of SiC during the fiber optic drawing process.

In the prior art, the significance or importance of "gap" size (spacing) between the preform (P) and the graphic liner is not given much consideration. However, it has been found that the maintenance of the air gap G in a range of 3.5 to 7.5 millimeters between the preform (P) and graphite liner 12 minimizes graphite particulate contamination of the preform P and fiber F during the fiber optic drawing process, and also minimizes the formation of SiC during the fiber optic drawing process.

The Scope of the Invention

It is also to be understood that the claims are intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween. For example, the scope of the invention is intended to cover a fiber

optic draw furnace having one or more of the aforementioned improvements.

Claims

1. A fiber optic draw furnace (10) having a heating element (22) arranged inside a furnace shell (20) for drawing an optical fiber (F) from a preform (P), having one or more fiber draw furnace insulation means (14, 16, 18) to separate the heating element (22) from the furnace shell (20) for reducing the thermal transfer therebetween,
   wherein at least one of the fiber draw furnace insulation means (14, 16, 18) is made from rigidified high purity graphite felt that provides highly efficient thermal insulation between the heating element (22) and the outer furnace shell (20).

2. A fiber optic draw furnace (10) according to claim 1, wherein the one or more insulation means (14, 16, 18) includes either a bottom insulation ring (14), a cylindrical insulation insert (16) or a cylindrical insulation canister (18).

3. A fiber optic draw furnace (10) according to claim 2,
   wherein the fiber optic draw furnace (10) includes a bottom insulation plate (24) having a titanium coating; and
   wherein the bottom insulation ring (14) in arranged between the bottom insulation plate (24) and the outer furnace shell (20).

4. A fiber optic draw furnace (10) according to claim 2,
   wherein the fiber optic draw furnace (10) includes an inner cylinder plate (26) having a titanium coating that is arranged around the heating element (22); and
   wherein the cylindrical insulation insert (16) is arranged around the inner cylinder (26).

5. A fiber optic draw furnace (10) according to claim 2,
   wherein the fiber optic draw furnace (10) includes an inner cylinder plate (26) having a titanium coating that is arranged around the heating element (22); and
   wherein the cylindrical insulation canister (18) is arranged between the cylindrical insulation insert (16) and the outer furnace shell (20).

6. A fiber optic draw furnace (10) according to claim 1, wherein the fiber optic draw furnace (10) is a graphite resistance furnace.

7. A fiber optic draw furnace (10) according to claim 1, wherein the fiber optic draw furnace (10) is an inductance furnace.

8. A fiber optic draw furnace (10) according to claim 1, wherein the fiber optic draw furnace (10) further comprises:

   an outer furnace shell (20);
   a bottom insulation plate (24) having a titanium coating and being arranged in the outer furnace shell (20);
   a bottom insulation ring (14) made of rigidified high purity graphite felt having a reflective coating and being arranged between the bottom insulation plate (24) and the outer furnace shell (20);
   an inner cylinder plate (26) having a titanium coating and being arranged around the heating element (22) and resting on the bottom insulation plate (24);
   a cylindrical insulation insert (16) made of rigidified high purity graphite felt having a reflective coating and being arranged around the an inner cylinder (26) and resting on the bottom insulation plate (24); and
   a cylindrical insulation canister (18) made of rigidified high purity graphite felt having a reflective coating and being arranged between the insulation insert (16) and the outer furnace shell (20).

9. Fiber draw furnace insulation (14, 16, 18) for a fiber optic draw furnace (10) that draws an optical fiber (F) from a preform (P), the fiber optic draw furnace (10) having a heating element (22) arranged inside a furnace shell (20),
   wherein the fiber draw furnace insulation (14, 16, 18) is shaped to be arranged between the heating element (22) from the furnace shell (20) for reducing the thermal transfer therebetween,
   wherein the fiber draw furnace insulation (14, 16, 18) is made from rigidified high purity graphite felt that provides highly efficient thermal insulation between the heating element (22) and the outer furnace shell (20).

10. Fiber draw furnace insulation (14, 16, 18) according to claim 9, wherein the fiber draw furnace insulation (14, 16, 18) is a bottom insulation ring (14).

11. Fiber draw furnace insulation (14, 16, 18) according to claim 9, wherein the fiber draw furnace insulation (14, 16, 18) is a cylindrical insulation insert (16).

12. Fiber draw furnace insulation (14, 16, 18) according to claim 9, wherein the fiber draw furnace insulation (14, 16, 18) is a cylindrical insulation canister (18).

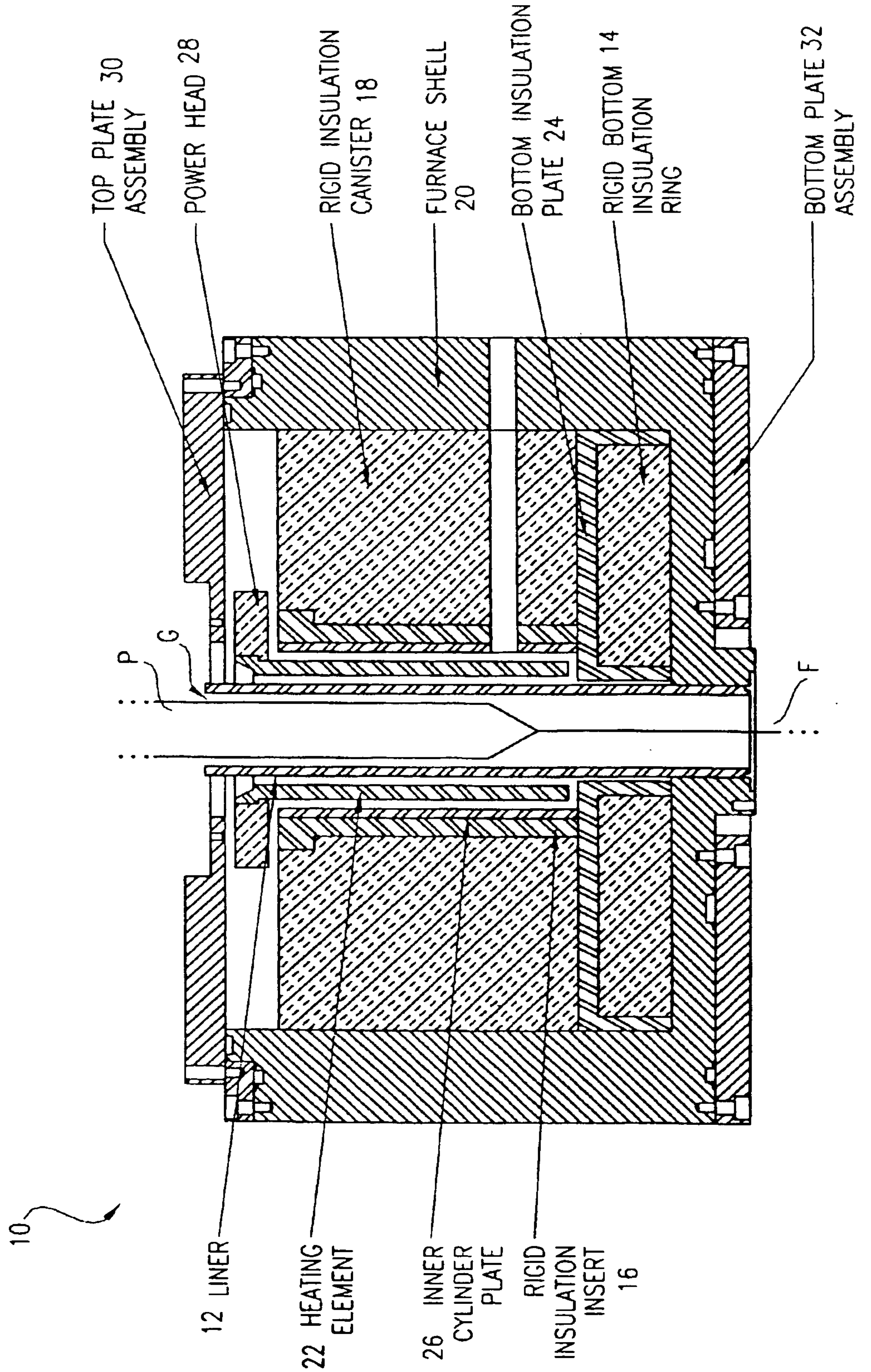
TOP PLATE 30
ASSEMBLY
POWER HEAD 28
RIGID INSULATION
CANISTER 18
FURNACE SHELL
20
BOTTOM INSULATION
PLATE 24
RIGID BOTTOM 14
INSULATION
RING
BOTTOM PLATE 32
ASSEMBLY
P
G
F
10
12 LINER
22 HEATING
ELEMENT
26 INNER
CYLINDER
PLATE
RIGID
INSULATION
INSERT
16

FIG. 1

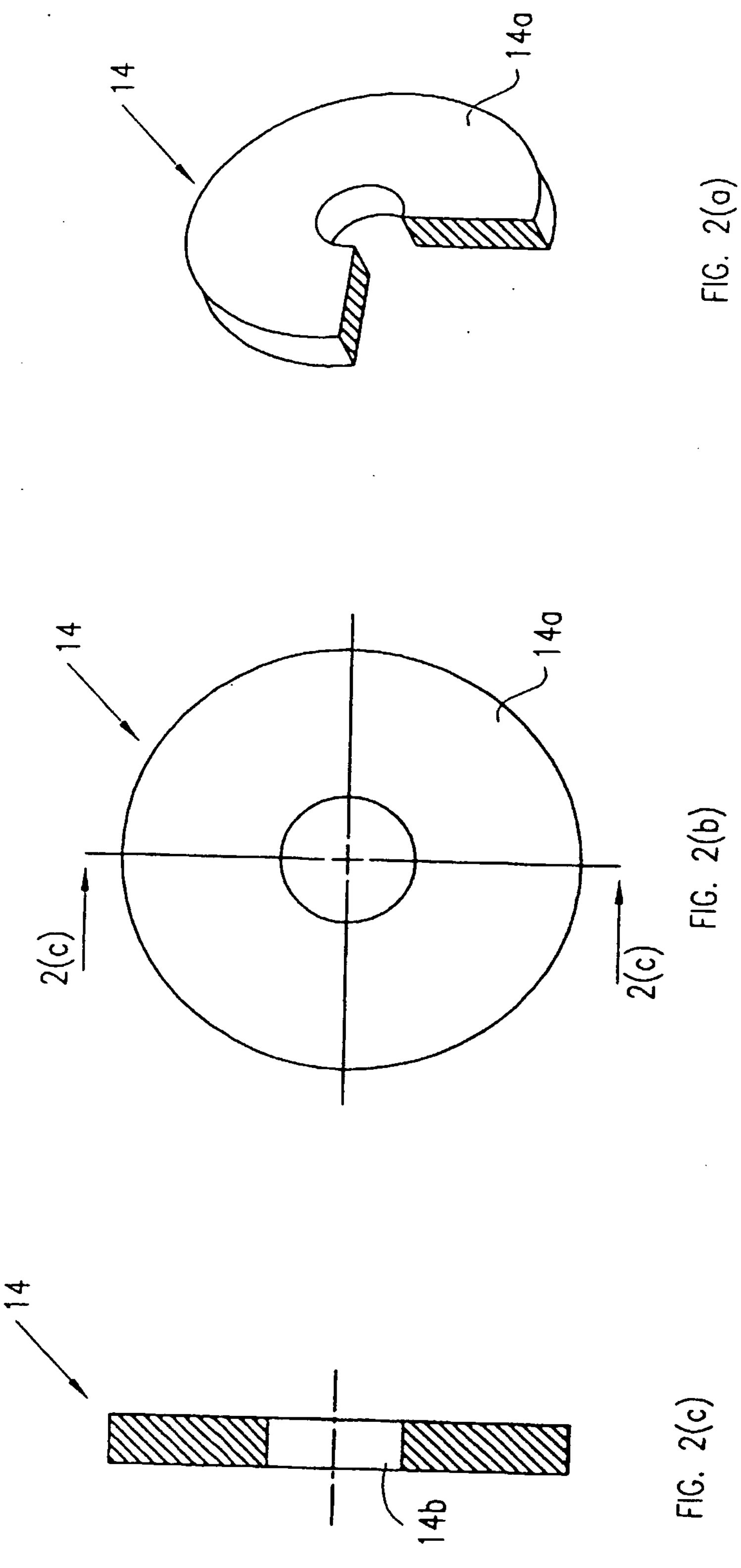

FIG. 2 (RIGID BOTTOM INSULATION RING)

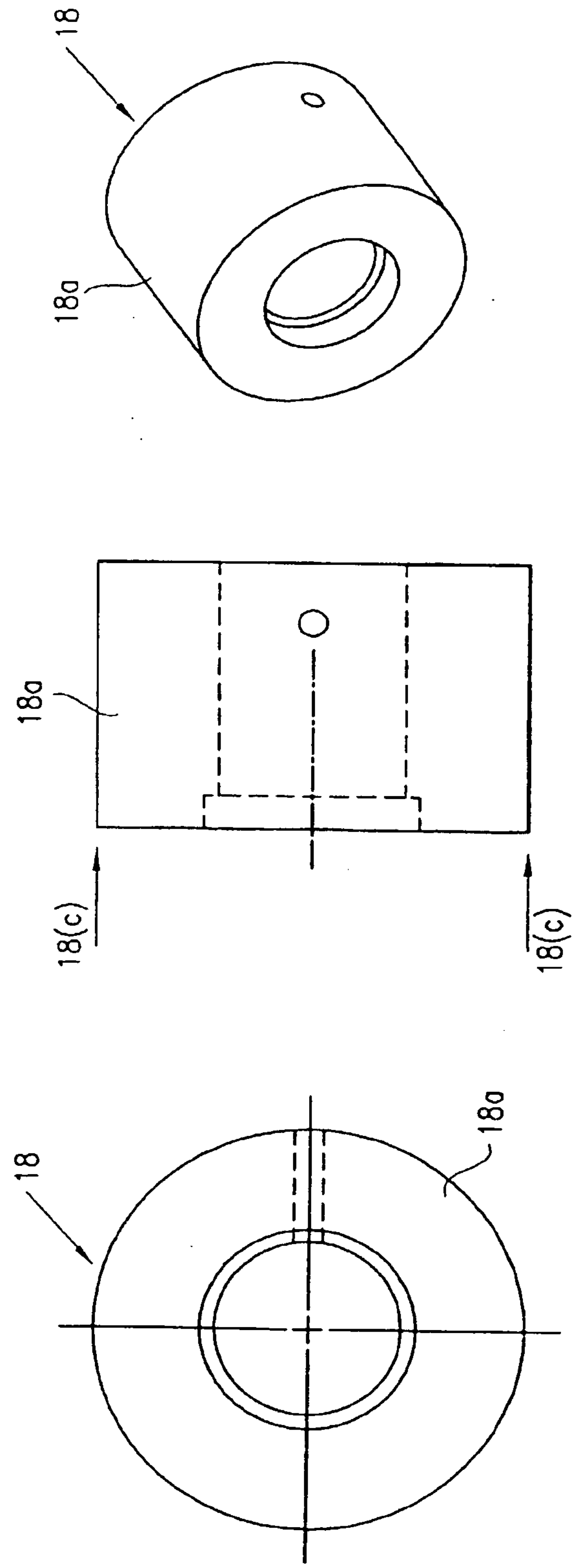

FIG. 3(a)

FIG. 3(b)

FIG. 3(c)

FIG. 3 (CANISTER)

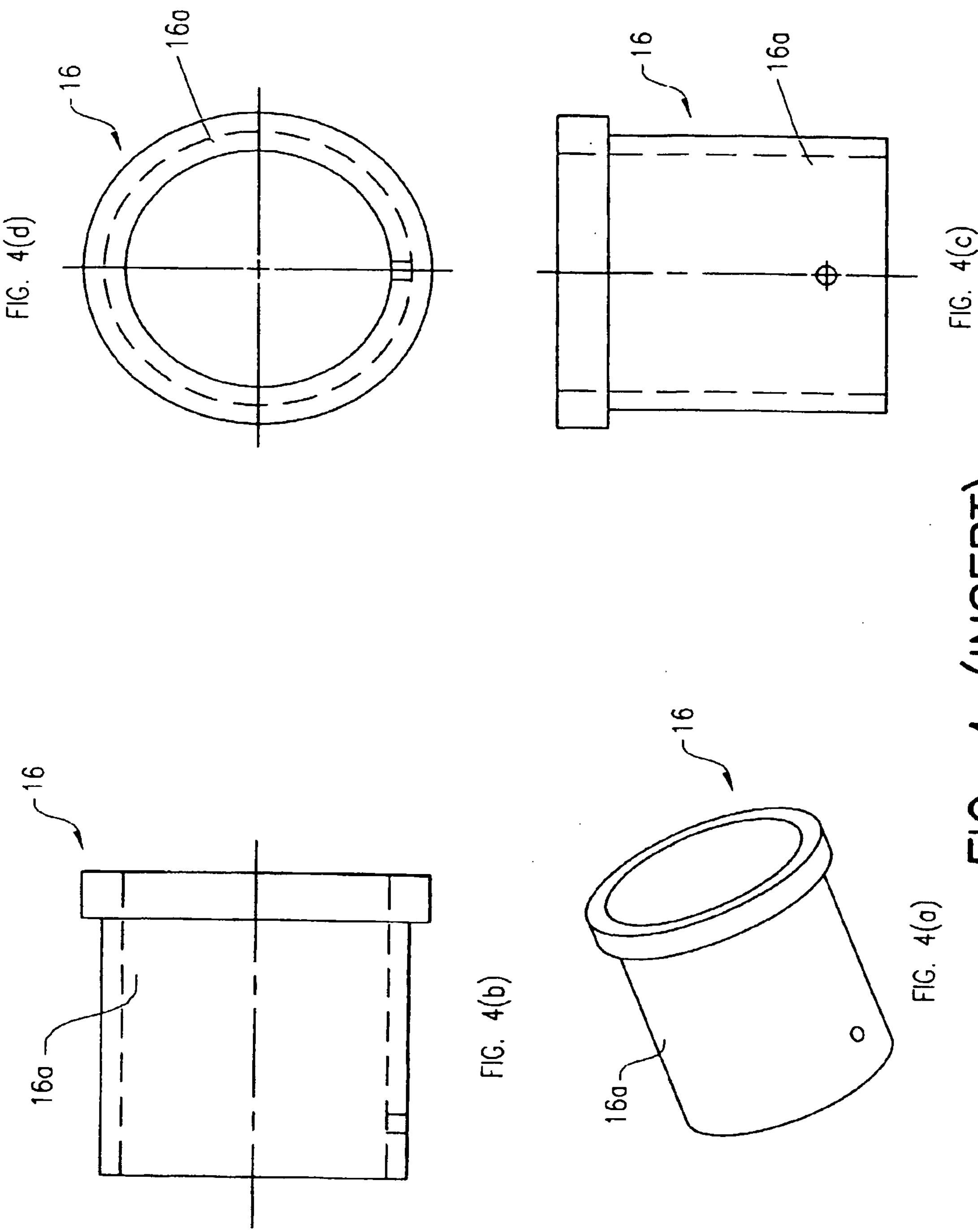

FIG. 4 (INSERT)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 40 0666

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	FR 2 386 004 A (CGE SA) 27 October 1978 * page 5, line 33 - line 39; figure 1 *	1,9	C03B37/029
A	PATENT ABSTRACTS OF JAPAN vol. 095, no. 006, 31 July 1995 & JP 07 081967 A (MITSUBISHI CABLE IND LTD), 28 March 1995, * abstract *	1,9	
A	GB 2 218 789 A (SUMITOMO ELECTRIC IND LTD) 22 November 1989 * page 1, paragraph 1 - page 3, paragraph 1; figure 3 * * page 5, last paragraph - page 6, paragraph 1 *	1,9	
A	DE 30 25 680 A (SIEMENS AG) 4 February 1982 * page 6, line 32 - line 36; figure 1 *	1,9	
A	US 4 279 952 A (F.KODAMA ET AL.) 21 July 1981		
A	GB 1 223 080 A (SIGRI ELEKTROGRAPHIT GMBH) 17 February 1971		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

C03B
H05B
F16L
F27D
F27B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 June 1998	Stroud, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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